SMES-ETM

TECHNICAL ANALYSIS REPORT

(Deliverable 4.6)

28 NOVEMBER 1989

DMSS/BERGER

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Accession Number: 4470

Publication Date: Nov 28, 1989

Title: SMES-ETM, Technical Analysis Report

Corporate Author Or Publisher: DMSS/BERGER Report Number: Deliverable 4.6

Comments on Document: Deliverable 4.6

Descriptors, Keywords: SMES ETM GFI EIAP Environmental Issue Report Magnetic Field Site Constraint

Pages: 00013

Cataloged Date: Apr 22, 1993

Document Type: HC

Number of Copies In Library: 000001

Record ID: 26735

Preface

The Technical Analysis Report (TAR) is the sixth deliverable of thirteen reports and briefings to be prepared under Task Four, Environmental Technical Support for SDIO/ENEC; Superconducting Magnetic Energy Storage (SMES-ETM) System EIAP/Siting Support. This TAR is prepared in accordance with the SMES-ETM Environmental Impact Assessment Process (EIAP) Implementation Plan (Deliverable 4.2). The EIAP Implementation Plan provides the overall framework within which the environmental impact assessment process for the SMES-ETM Program occurs. The EIAP Implementation Plan is designed to be consistent with the requirements of the National Environmental Policy Act (NEPA). The Technical Analysis Report is a major component of the SMES-ETM environmental impact assessment process. The TAR includes possible courses of action available to DNA and SDIO in determining the appropriate level of environmental documentation for the SMES-ETM Program.

The following table illustrates the series of reports and briefings required under Task 4, submittal dates of completed tasks, and scheduled submittal dates from Notice to Proceed (NTP) for remaining tasks. The Technical Analysis Report is presented below in relation to the other SMES-ETM deliverables.

SCHEDULE FOR TASK FOUR DELIVERABLES
NOTICE TO PROCEED 14 AUGUST 1989

DELIVERABLE	TITLE	STATUS
4.1	BRIEFING: TASK SUMMARY	COMPLETED 30 AUGUST 89
4.2	REPORT: DRAFT EIAP IMPLEMENTATION PLAN	COMPLETED 28 SEPTEMBER 89
	REPORT: FINAL EIAP IMPLEMENTATION PLAN	COMPLETED 28 NOVEMBER 89
4.3	REPORT: DRAFT DOPAA	COMPLETED 11 OCTOBER 89
4.4	REPORT: FINAL DOPAA	IN PROGRESS COMPLETION: 28 NOVEMBER 89
4.5	REPORT: ENVIRONMENTAL ISSUES SUMMARY	COMPLETED 17 NOVEMBER 89
	REPORT: TECHNICAL WHITE PAPER; Electromagnetic Effects	COMPLETED 13 NOVEMBER 89
4.6	**REPORT: TECHNICAL ANALYSIS**	**COMPLETED 28 NOVEMBER 89**
4.7	BRIEFING: TECHNICAL ANALYSIS	IN PROGRESS COMPLETION: 1 DECEMBER 89
4.8	REPORT: PRELIMINARY DRAFT ENVIRONMENTAL ASSESSMENT	165 DAYS FROM NTP
4.9	RESPOND TO COMMENTS PRELIMINARY DRAFT ENVIRONMENTAL ASSESSMENT	190 DAYS FROM NTP
4.10	REPORT: DRAFT ENVIRONMENTAL ASSESSMENT	205 DAYS FROM NTP
4.11	REPORT: DRAFT FINDING OF NO SIGNIFICANT IMPACT	205 DAYS FROM NTP
4.12	REPORT: DRAFT ENVIRONMENTAL ASSESSMENT MEETING	210 DAYS FROM NTP
4.13	REPORT: FINAL ENVIRONMENTAL ASSESSMENT	240 DAYS FROM NTP

1.0 Introduction

The purpose of the Technical Analysis Report is to provide SDIO and DNA with an appropriate level of information and analysis that will form the basis upon which the level of environmental documentation for the SMES-ETM Program is determined. Specifically, this report will support the SDIO-ENEC and DNA decision on whether an Environmental Assessment or an Environmental Impact Statement is most appropriate. This effort includes a review of work activities and a summary of salient environmental issues. Identification of possible courses of action and the corresponding implications of those actions are also presented.

The TAR builds upon the information presented in the Environmental Issues Summary Report (Deliverable 4.5). The purpose of that document was to provide SDIO and DNA with an overall picture of those environmental issues associated with the SMES-ETM that have been indicated as potentially significant. The TAR examines those potentially significant issues in terms of actions that could mitigate negative effects. Choosing a particular set of mitigations, or courses of action, may lead to a determination of whether an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) is the most appropriate form of environmental documentation for the SMES-ETM Program.

2.0 Subtask Findings

2.1 SMES-ETM GFI Familiarization (Subtask 4.1)

All Government Furnished Information (GFI) that was applicable to the SMES-ETM and SMES-ETM technology was reviewed in order to determine the comprehensiveness and adequacy of the existing information. The subtask work efforts provided a general overview of the data, the adequacy of the data, and additional data requirements. In general, the quality of the GFI varied in detail and scope of coverage. The quantity of information also varied greatly between the five SMES-ETM candidate sites. The quality and quantity of the information provided in the GFI review was sufficient, however, as an overview of conditions for these sites. The GFI review also identified areas where additional data requirements were necessary. The numerous data gaps precluded sole reliance on these GFI documents as a basis for the determination of potentially significant environmental issues. This work effort resulted in Deliverable 4.1. Task Summary Briefing; SMES-ETM GFI Familiarization, completed 30 August 1989.

2.2 SMES-ETM EIAP Implementation Plan (Subtask 4.2)

The Environmental Impact Assessment Process Implementation Plan provides the framework within which an EA or an EIS will be prepared for the SMES-ETM Program. The framework provides a means of managing and documenting the SMES-ETM environmental process so as to be consistent with all provision in NEPA, DoD 6050.1, and DNA 6050.1.

The purpose for developing the framework is to serve as an overall guide for managing the SMES-ETM Environmental Impact Assessment Process and coordinating the roles and responsibilities between SDIO-ENEC, DNA, and other SDIO staff.

The goals toward which the EIAP are directed are five-fold. First, the Implementation Plan allows DNA and SDIO to maintain the overall SMES-ETM Program schedule by ensuring timely completion of the interrelated tasks in the environmental impact assessment process. Second, the Implementation Plan is to create an understanding of the process for those managing the effort in order to accomplish the EIAP in as efficient and cost effective means as possible. The third goal of the Implementation Plan is to function as a monitoring tool so that the mangers know where they are in the EIAP at a given time and to ensure that the resources being committed are done so efficiently.

The fourth goal is to ensure that all managers in the process have a clearer and articulate understanding of their respective roles and responsibilities for which they will be held accountable. The fifth and final goal is to ensure that prior analysis being conducted on the proposed SMES-ETM Program, all analysts and managers have a common understanding of the total known scope for which the appropriate environmental documentation is being prepared.

As a guide for EIAP activities the Implementation Plan (Deliverable 4.2) coordinates the development of all subtasks that lead to this Technical Analysis Report. Documents such as GFI Familiarization, DOPAA, and Environmental Issues Summary Report, build on one another in order to provide to SDIO and DNA as comprehensive an overview as is possible of the environmental issues associated with the SMES-ETM Program.

2.3 Description of Proposal Action and Alternatives [DOPAA (Subtask 4.3)]

The DOPAA has been designed to serve as the environmental baseline SMES-ETM system configuration control document.

The design, construction and testing of the SMES-ETM is presently in competition. Bechtel National, Inc. and Ebasco Services, Inc. will submit detailed concept design and construction proposals to the government in May 1990. In November 1990, one of the two companies will be chosen to construct the SMES-ETM. Therefore, the DOPAA describes the current SMES-ETM concept in terms which necessarily incorporate a range of values. The DOPAA focuses on those system parameters which drive environmental impacts. As the baseline system concept and designs evolve and when a point design is chosen, system changes affecting the environment will be added through amendments or revision to the DOPAA. Thus, the DOPAA is a living document which tracks and documents the SMES-ETM system parameters that could affect the environmental analysis.

This subtask has resulted in the production of the deliverables, 4.3, the Draft Dopaa Report and 4.4, the Final DOPAA Report.

2.4 Environmental Issues Summary Report (Subtask 4.4)

The purpose of the Environmental Issues Summary Report (Deliverable 4.5) is to provide DNA and SDIO with an overall picture of the potentially significant environmental issues associated with the SMES-ETM Program. These issues are related to SMES-ETM technology, general construction practices that are generic

to all sites, and site specific constraints. The potentially significant issues were determined by screening all environmental issues against the NEPA criteria for significance.

During the preparation of the Preliminary Environmental Issues Summary, a parallel effort was undertaken on potential technology specific environmental issues. This effort resulted in a separate white paper on electromagnetic effects that was integrated into the final version of the Environmental Issue Summary Report. Therefore, the document presents both technology and site specific issues for consideration by DNA and SDIO.

These issues form the basis of this Technical Analysis Report.

3.0 Analysis of Potentially Significant Environmental Issues

The potentially significant environmental issues associated with the SMES-ETM Program are contained in Deliverable 4.5, Final Environmental Issues Summary Report. While these issues include technology considerations, general construction practices that are common to all sites, and site specific constraints, issues relating to SMES-ETM technology stand out as having the greatest implications for the SMES-ETM EIAP.

3.1 Technology Issues

Technology Issues

The major technological concerns are related to the electromagnetic fields produced by a SMES-ETM and the transmission line connecting it to the electrical grid system. Electromagnetic fields are divided into two components: electrical fields and the magnetic fields. Alternating electrical currents (AC) produce oscillating, or time-varying, electrical and magnetic fields which can in turn produce electromagnetic waves (radiation). The types of fields of concern are the strong steady magnetic fields produced by the SMES-ETM coil and the much weaker oscillating electromagnetic fields produced by the transmission lines connecting the SMES-ETM to the electrical grid, the converter which converts AC to DC to feed the SMES-ETM and DC to AC to draw energy from the SMES-ETM and by the "ripple" in the DC current in the SMES-ETM coil. To effectively produce radiation, the radiator has to be as large as the wave. As the transmission lines operate at the extremely low frequency of 60 Hz, the wave-length of the radiation produced is extremely long. Therefore, neither the SMES-ETM or its connections to the grid will produce significant radiation.

The two areas of concern are dangers to public health and impacts on wildlife and particularly birds. Recent public concern on the health risks associated with electromagnetic fields relate to the time-varying fields produced by transmission lines and radio stations and the electromagnetic radiation produced by radio and radar stations. The major concern related to wildlife is the possible impact of the strong steady magnetic fields produced by a SMES-ETM coil on the navigation systems of migratory birds. In both cases, studies have indicated a possible relationship but in neither case have the relationships

been proven scientifically.

The effects of steady magnetic fields on humans and other species are relatively well known and it is comparatively easy to protect humans from any danger. For example, conductors moving in a magnetic field generate an eddy current. Blood moving through our veins is a conductor. But blood moves extremely slowly and veins are small and therefore an extremely strong field is necessary to generate a current which will effect humans. The general public will be excluded from areas of high magnetic fields by the facility's perimeter fence and it is assumed that facility employees will be protected by the application of appropriate safety rules and practices. The application of such practices is not addressed as an environmental issue. The only area of significant concern is that the perimeter fence line is to be placed at the 10 gauss contour. Certain types of artificial cardiac pacemakers are effected at fields as low as 8 gauss and their reed switch may close in fields of 13/14 gauss. The closing of the reed switch causes the pacemaker to change from a synchronous to asynchronous mode. Doctors use magnets to change a patient's pacemaker to asynchronous mode during check-ups and this is done by some patients for remote testing of pacemakers over the telephone. Such changes of mode are unlikely to be dangerous except to patients with extremely weak hearts but it is considered medically undesirable for pacemakers to change into the asynchronous mode in an uncontrolled environment.

The FDA requires nuclear magnetic resonance imaging equipment to contain a warning statement addressing the risk to persons with cardiac pacemakers or other implanted electronic devices who enter a zone where the magnetic field exceeds 5 gauss[1]. It is also reported that the 5 gauss line is painted on floors of hospitals in Japan to exclude people with pacemakers[2]. To protect people with pacemakers, the Lawrence Livermore National Laboratory (LLNL) set a 10 gauss limit for their magnetic confinement experiment and the Japanese Railways are also proposing a 10 gauss limit for the passenger compartment of their mag-lev trains. However, the LLNL limit was set to avoid the relocation of a major road[3] and there is controversy over the Japanese Railways proposal.

It is recommended that the facility perimeter fence line be placed at the 5 gauss contour or that signs be placed at the 5 gauss contour to warn wearers of pacemakers. If this is done and access inside the fence is restricted, steady magnetic fields are unlikely to impact public health. The use of warning signs rather than the installation of a fence at the 5 gauss contour is unlikely to have any medical consequences but it may increase public controversy. The placing of the SMES-ETM offices and control center outside the 5 gauss contour should also be considered.

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[1] Food and Drug Administration, Labelling for a NMR Imaging Product, Draft of August 24, 1984, Rockville, MD 20857

[2] Railway Gazette International, Keep off the Gauss, p. 704, October 1989

[3] Miller, G., Exposure Guidelines for Magnetic Fields, Am. Ind Hyg. Assoc. J. 48(12):962 (1987)

The effects on wildlife of the SMES-ETM are principally related to those organism which could be exposed to the magnetic field produced by the facility. Studies have been conducted to establish the effects of magnetic fields on organisms ranging from bacteria to man. Because the ETM facility will be enclosed by a fence, it is possible to exclude most organisms from the higher magnetic fields. Birds could be exposed to magnetic fields which may affect their orientation.

Most authorities appear to agree that magnetic fields may impact the navigation mechanisms of migratory birds. However, the literature suggests that effects may not be more than transient. Numerous studies have been conducted to determine effects of magnetic fields on avian navigation. Many of these studies used homing pigeons as the experimental organism and examined the effects of the birds' initials flight direction when released at a site distant from the home loft. While some studies showed the birds's initial flight direction was effected by magnetic fields between 0.1 and 0.6 Gauss, the birds' return to their home loft were not effected. Exposure to much higher magnetic fields, 10 tesla (T) for one minute, resulted in disorientation of homing pigeons for a period of up to six weeks. While the higher magnetic fields of the ETM will be less than 10 T, approximately 2.3 T, the effects of this magnetic field and the lower magnetic fields of the facility on migrating birds passing overhead are unknown. These effects may be significant if the species affected are threatened or endangered and the magnetic fields disrupt their life cycles. Another potentially significant effect would be the disruption of species of local importance which could raise the concern of the public.

Two of the five sites are of particular concern regarding this issue, Badger Army Ammunition Plant (BAAP) Site in Baraboo, Wisconsin, and Hanford Reservation Site in Washington. The potential for interaction between the magnetic field and birds is highest at these locations.

The BAAP is located near Baraboo bluffs which is one of the largest forested areas left in Wisconsin and is a major habitat for songbirds, falcons, and hawks. One hundred thirty five different species have been identified of which eleven have either federal or state special status. In addition, the State of Wisconsin is attempting to introduce the peregrine falcon to the bluffs. The eleven species include:

- Cooper's Hawk
- Acadian Flycatcher
- Bell's Vireo
- Cerulean Warbler
- Hooded Warbler
- Peregrine Falcon (introduced)
- Red-shouldered Hawk
- Bewick's Wren
- Wormeating Warbler
- Kentucky Warbler
- Bald Eagle

The 10 gauss field level is reached, horizontally, at approximately 1,000 feet

from the center of the ETM coil. Vertically, this distance increases to approximately 1,200 feet. To reach a vertical field of 2 gauss, the distance would be extended to approximately 2,500 feet, well past the 2,000 foot minimum cruising altitude common for migrating birds. The Cooper's and Red-shouldered Hawks, both Wisconsin State Threatened Species would enter this zone during feeding runs in search of mice and other small mammals. This would also be true for the peregrine falcon, a federal and state endangered species. Songbirds would be exposed during migration period as well as during daily runs from their nesting areas in search of seed and other food items.

Approximately 20 bald eagles have been observed roosting and feeding within 2-3 miles of BAAP. A potential for interaction with the magnetic field exists although the potential is low. The primary feeding habitat for the eagles appears to be below a dam on the Wisconsin River where fishing activity can occur during the winter. The river in this area does not freeze due to water flow from the dam. The eagle's roosting area is adjacent to the river.

The potential for magnetic affects on avian species exists for several protected birds at the Hanford Site and could possibly result in direct effects on the long-billed curlew.

The sand hill crane, which is on the threatened/endangered species list, has been observed flying over the area, but evidence of nesting in the vicinity is inconclusive. The bald eagle could also be affected. Three federal candidate species that use the site could be affected: swainson hawks, ferruginous hawks and the long-billed curlew.

The potential for interaction with the magnetic field is two-fold. First, the swainson and ferruginous hawks and other birds of prey may enter the zone during feeding runs. Second, the long-billed curlew, which uses the Columbia River adjacent to the Hanford Reservation, may intersect the 1,200 foot zone while entering or leaving roosting and feeding areas. Sandhill cranes may also fly through the zone during migration dependent on proximity of roosting to the river and to the proposed Hanford site. Additionally, these birds may be affected at the 2 gauss level and even the .61 gauss level (approximately 3,500 feet) during typical migrating seasons.

The other three sites are of less concern due primarily to the lack of water in the respective areas. However, while of less concern, potential for effect still exists. At the Orogrande and White Sands Missile Range sites in New Mexico, five federally listed threatened and/or endangered species are known to inhabit the area, but not specifically the sites. The listed species are: the American peregrine falcon, aplomado falcon, bald eagle, whooping crane, and interior least tern. The sites are within the feeding range of the falcons and eagles which could, therefore, lead to these species entering the magnetic field in search of prey. It is less likely that the whooping crane and interior least tern would be affected during flight or migration due to the absence of significant bodies of water in the area. However, these birds as well may be affected at the 2,000 foot to 3,500 foot level during typical over-flight migration.

The Monahans site is located under an avian flyway. Since water is not available in the immediate area birds may not inhabit the area long enough to experience any potential adverse effects. However disorienting effects may occur during seasonal migration, again between the 2,000 foot and 3,500 foot elevations for threatened and endangered species listed in the area. These species include the American peregrine falcon, arctic peregrine falcon, bald eagle, interior least tern, piping plover, black-capped vireo, and possibly the whooping crane.

To mitigate the potential effects of the magnetic fields on birds it would be advantageous to limit their exposure. It should be realized that shielding the SMES-ETM to drastically reduce the magnetic field would eliminate much of the concern of this issue. While this mitigation measure may be impracticable due to site, engineering or cost constraints, shielding should be re-examined.

In addition to shielding, limiting avian exposure could be accomplished by several means:

- Attraction to the facility itself could be minimized by removing vegetation which would provide nesting and foraging habitats for birds.
- The presence of prey for birds (small mammals and reptiles) could be minimized by fencing out these species and reducing their desire to inhabit the site by eliminating their food sources.
- Birds can effectively be kept from landing in an area by installing monofilament line in a grid pattern over the area to be excluded or by subjecting the area to periodic loud noises (air cannon).
- To minimize the potential effects on birds migrating over or near the area, the use of the facility could be discontinued during time of peak migration.

It is recommended that all the above mitigation measure be considered. These measures should minimize the potential effects on avian species. It is possible that even with these mitigation measures in place, resident or over-wintering birds may be affected by the facility.

In addition to these mitigation measures, it is recommended that as part of the testing program of the SMES-ETM, controlled experiments should be performed to determine the effects of the SMES-ETM on birds. These experiments should be conducted during non-migratory periods using birds such as homing pigeons. If the SMES-ETM does not have a significant effect on the navigation of the test birds, a limited SMES-ETM trial during migration could be conducted to determine the effects on other species. If this trial did not have a significant effect on avian migration, full time use of the SMES-ETM could be implemented.

These mitigation measures and experiments have implications on the environmental conditions of the site. Denuding the site would increase the erosion potential of the site and mitigation for this erosion impact would have to be implemented. If air cannons are used to deter birds from the site, noise impacts may be an issue depending on proximity of sensitive receptors. Testing the SMES-ETM during

non-migratory periods will require the cooperation of the testing agencies and the utilities, and it may require curtailing an ongoing test, if the test extends into the migratory season. Disruption of the SMES-ETM testing schedule may disrupt implementation of the full-scale SMES-ETM.

There has been increasing concern over the health impacts of oscillating electromagnetic fields from power lines and radio/radar stations. A number of epidemiological and experimental studies have linked various forms of cancer and other undesirable human health effects with these electromagnetic fields. Recent experimental work has demonstrated possible biological processes causing these effects. A recent series of articles in the New Yorker Magazine has highlighted these concerns among the public[4].

Until the early 1970s it had been assumed that time-varying electromagnetic fields in the power distribution frequency range posed no risk to human health. There is no significant transfer of energy which, like X-rays, could break chemical bonds, or like microwaves, could cause body heating. Cells maintain large natural electrical fields across their outer membranes which are at least 100 times as large as those to which people are exposed.

More recently a number of epidemiological studies have pointed to the possible association of health impacts, including certain forms of cancer, to time-varying electrical ad magnetic fields. Individually these studies can all be faulted and contradictory results have been produced by some studies. A consensus appears to be developing among many scientists that the sum of these studies indicate the suspicion of an association which needs to investigated further. Other scientists maintain that the weaknesses of the these studies do not allow any inference of an association to be drawn. Public opinion, currently deeply suspicious of technological developments, is likely to side with those believing in the association.

Recent experimental studies demonstrate that weak time-varying electrical and magnetic fields appear to interfere with the signalling system which controls cellular functions. Among the responses that have been demonstrated in studies using animal cells and tissues are:

- Modulation of ion flows, including calcium which acts as a messenger;
- Interference with DNA synthesis and RNA transcription;
- Interaction with the response of normal cells to various agents and biochemicals such as hormones, neurotransmitters and growth factors;
- Interaction with the biochemical kinetics of cancer cells.

Many of these experiments have only demonstrated responses at specific

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[4] Brodeur P., Annals of Radiation: the Hazards of Electromagnetic Fields, New Yorker Magazine, June 12, 19 and 26, 1989

frequencies, field strengths or in combination with some other factor such as a steady magnetic field. No theoretical model has been developed to explain these phenomena.

In order to establish a relationship between electromagnetic fields and health problems such as cancer it is necessary to establish a dose-response relationship. Such a relationship has been established for cigarette smoking and lung cancer for example. No such relationship has been established for electromagnetic fields.

In summary, therefore, the current state of knowledge is that there are indicators pointing to the possible health hazards of time-varying electromagnetic fields but a relationship has not been demonstrated. This state of knowledge existed for many years before the health impacts of such well known carcinogens as smoking and asbestos were established. Therefore, it is prudent to take these indicators seriously.

The SMES-ETM coil carries a DC current which has a ripple which is caused by the conversion from AC and which produces a time-varying magnetic field. Contractors have indicated that by necessity for the SMES-ETM coil to function, the ripple will be small but that the exact size will be established only after the ETM has been put into operation.

It should be relatively easy to place the transmission lines and converter station away from human habitations to virtually eliminate health risks. However, the precise location of the transmission lines and converter stations and the transmission voltages have not been indicated at this stage.

While it is expected that it will be possible to demonstrate that neither the transmission/conversion system nor the SMES-ETM coil will pose any risk to public health, it is not possible to document this at this stage. It is recommended that the precise locations, voltages and field strengths of the transmission system be defined before the EA or EIS is finalized so that the low risk may be documented.

Further, contractors should state the maximum ripple and time-varying fields to be produced by the SMES-ETM coil which they are able to guarantee, again, so that the low health risks associated with them may be documented.

3.2 General Construction Practices

The only potentially significant environmental issue that has been identified and that is generic to all sites for which construction activities occur is cultural resources. All sites have the potential for significant archaeological or historic finds. However, this cannot be determined until complete site surveys or construction activities occur.

To date step 1A, literature search and reconnaissance inspection, has been conducted at each of the alternative sites. The identification of each site as potentially significant will not impact a decision on the NEPA process, but may affect construction costs and schedules, should extensive and significant

properties occur at the selected site. (Significant properties being those that meet the criteria for inclusion in the National Register of Historic Places.) The literature search and reconnaissance inspection, Phase IA, fulfills NEPA requirements so that subsequent activities fall within the 106 process.

3.3 Site Specific Constraints

Site specific constraints, in addition to magnetic effects on avian species, are few. At Hanford, several state species of concern use the site: northern grasshopper mouse, night snake and striped whipsnake. Although they are not listed as federally threatened and endangered species, they are listed as candidate species by the State of Washington. It is anticipated that the presence of these species will not interfere with siting the SMES-ETM at the proposed Hanford Site.

Sneed's Pincushion Cactus, and Lloyd's Hedgehog Cactus, threatened and endangered species may be located at the Orogrande and WSMR sites. This determination cannot be made until spring when flowering occurs.

The Jarilla mountains, which are located adjacent to the site and are disjunct from other mountains in the vicinity may contain distinct plant and animal species. Lloyd's Hedgehog Cactus is found on the mountain range.

Should either of these species be found at the proposed sites and should either Orogrande or WSMR be selected at the site for the SMES-ETM, a management plan should be developed for protection of the rare plant species and sensitive habitats. This plan would include avoidance where possible and could also include the possibility of transplanting the species.

3.4 Conclusions of Magnetic Field Effects and Issues Prepared by Bechtel National, Inc.

Bechtel National Inc. has also identified the need for further research into magnetic effects of SMES Technology in Engineering Test Model (ETM) Development Program. Phase I: Magnetic Field Effects and Issues, dated October 1989. Salient conclusions drawn by Bechtel National, Inc. include the following:

- SMES produces static (DC) magnetic fields in which energy is stored, with a maximum accessible static field of less than 2.5 tesla. The only known hazards from such fields are on metallic implants such as cardiac pacemakers. However, such hazards can be mitigated by establishing exclusion zones around the SMES plant.

- Recent media reports have expressed concern about the biological effects of magnetic fields. Unfortunately, the complexity of most organisms precludes development of realistic static magnetic field interaction models. Instead, most of the research in magnetic field effects is experimental. Many of these tests fail to document all variables of the problem; Other reports note changes at a microscopic level that may or may not be significant to the organism as a whole. It was also found that while some components of an

organism may be influenced adversely, compensating mechanisms may exist to mitigate the overall effect of the field. In essence, the conflicting array of documentation suggests that the long-term effects of the SMES magnetic field upon animals, particularly avian species that use geomagnetic fields to navigate, is preliminary and inconclusive. Biological testing upon avian species in conjunction with operation of the SMES-ETM however, could provide significant insights into the effects of magnetic fields upon bird navigation.

- Further research on the biological effects of static magnetic fields on humans indicate that SMES plants should pose no hazards if exclusion zones are established around the coil to prevent entry of the public into field strengths greater than 10 gauss, and workers into fields over 100 gauss. It is expected that these limits may prove conservative. The results of controlled tests performed in the SMES environment may suggest a relaxation of the conservative controls and exclusion zones currently planned for SMES plants. Available information indicates that non-biological effects of the SMES magnetic field outside the plant boundaries will be negligible.

4.0 Courses of Action/Recommendations

Based on the preceding discussions, four alternative courses of action are available to SDIO-ENEC and DNA. These four are: 1) Shielding, 2) Mitigation Program, 3) Mitigation and Research Program, and 4) No Mitigation.

1) Shielding - Should shielding of the SMES-ETM be incorporated, the potential for negative magnetic effects on avian species would be minimal. If this course of action is pursued, an Environmental Assessment would be appropriate.

2) Mitigation Program - Under this course of action the SMES-ETM site would be modified to deter local bird use. These modifications, or mitigations as previously discussed include:

   - removal of vegetation;
   - fencing out small mammals and reptiles;
   - installment of a monofilament grid; and
   - use of air cannons during operation of the SMES-ETM.

   If these mitigations are initiated, the potential for a significant impact resulting from magnetic effects is reduced. However, the potential effect on migratory birds would still be present. This is due to the .61 gauss field extending to approximately 3,500 feet which is above minimum migratory elevations of 2,000 feet. As was previously mentioned, studies indicate disorienting effects between 0.1 and 0.6 gauss, although the pigeons studied were able to return to their home loft. Other studies indicate disorienting effects for up to six weeks at the 10 Tesla level. Unfortunately, research in this area on species other than pigeons is minimal.

The difficulty lies in the lack of research conducted on magnetic field strengths between these two extremes. We can state that migratory birds will be exposed to magnetic fields of up to 4 gauss using a 2,000 migratory elevation minimum. In addition, each site has the potential for affecting avian species that are threatened or endangered although BAAP and Hanford could potentially affect a greater number and Monahans the least number of species with special status, as previously stated.

Therefore, given the lack of knowledge associated with the effects of SMES-ETM magnetic field strengths on avian species, an Environmental Impact Statement may be warranted. These unknown effects are considered potentially significant based on the significance criteria established in 40 CFR 1502.16. Specifically the following criteria for significance apply:

- The degree to which the effects on the quality of the human environment are likely to be highly controversial;
- The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks;
- The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

3) Mitigation and Research Program - This course of action would entail designing and implementing a research program into the mitigation program in order to determine the effects on avian navigation and animal behavior. As stated earlier; controlled experiments could be performed to determine the effects of the SMES-ETM on birds. These experiments should be conducted during non-migratory periods using birds such as homing pigeons. If the SMES-ETM does not have a significant effect on the navigation of the test birds, a limited SMES-ETM trial during migration could be conducted to determine the effects on other species. If this trial did not have a significant effect on avian migration, full time use of the SMES-ETM could be implemented.

The implications for this course of action are that results indicating significant negative effects could effect the operation of the SMES-ETM. This would lead to one of two possible courses of action. First, the SMES-ETM could be operated only during non-migration periods. Second, an Environmental Impact Statement could be prepared detailing the results of the research program and the intent to operate during migration season.

With all mitigation measures in place and a commitment to the above strategies, an EA would be appropriate.

4) No Mitigation - Should SDIO-ENEC and DNA not be in a position to propose mitigations to minimize the possible negative effects on avian navigation and animal behavior then an EIS would be warranted. This is due to the unknown effects associated with SMES-ETM generated magnetic fields on threatened and endangered species that 1) migrate over each of the

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candidate sites, and 2) use the local areas for roosting, nesting, and feeding. The unknown effects are considered potentially significant based on the criteria for significance identified in Course of Action #2.